AFSC Ecosystem Science overview and priority setting

Mike Sigler

NOAA FISHERIES

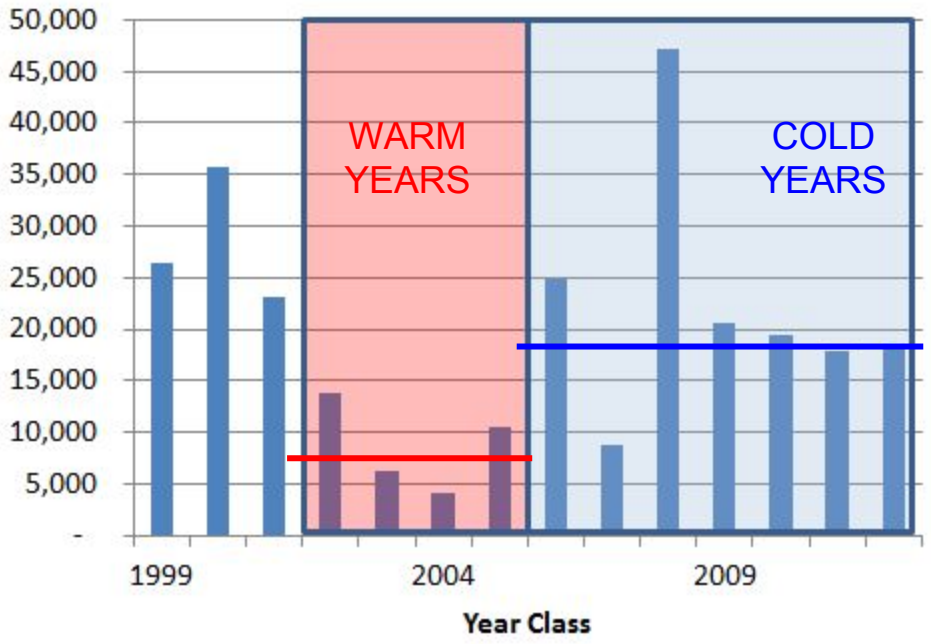
Alaska Fisheries Science Center

Ecosystem Science Review
Juneau, Alaska
May 2-6, 2016

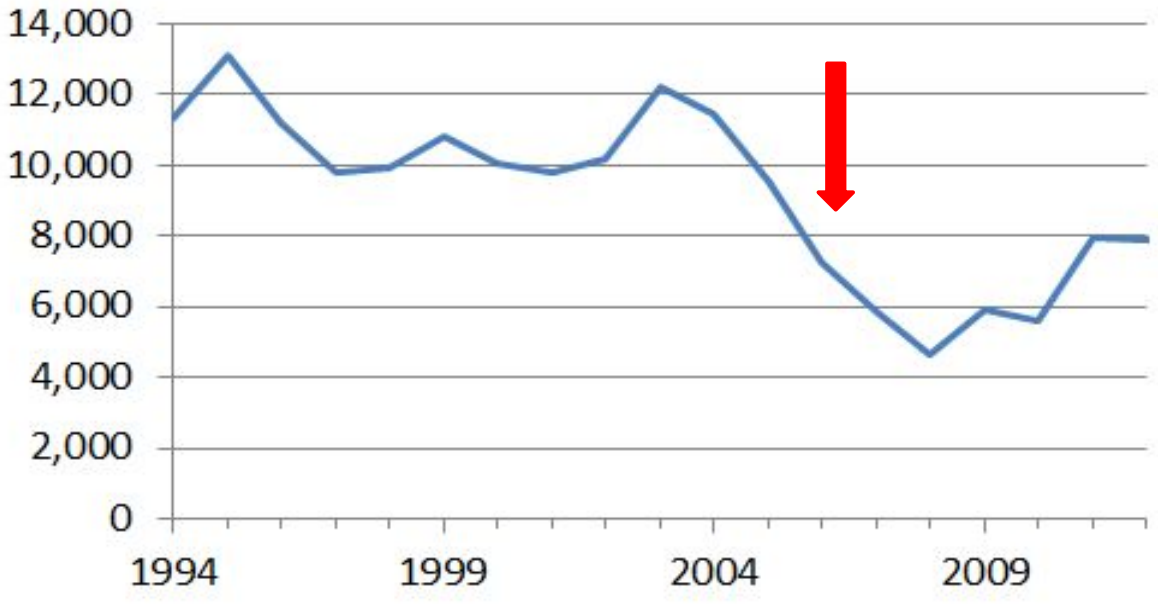
Climate and Fisheries

EXPLAIN THIS:

Walleye pollock abundance dramatically fell in the early 2000's, leading to a 40% drop in the quota for the largest single fishery in the US, and then rebounded.



Age-3+ Biomass (thousands t)

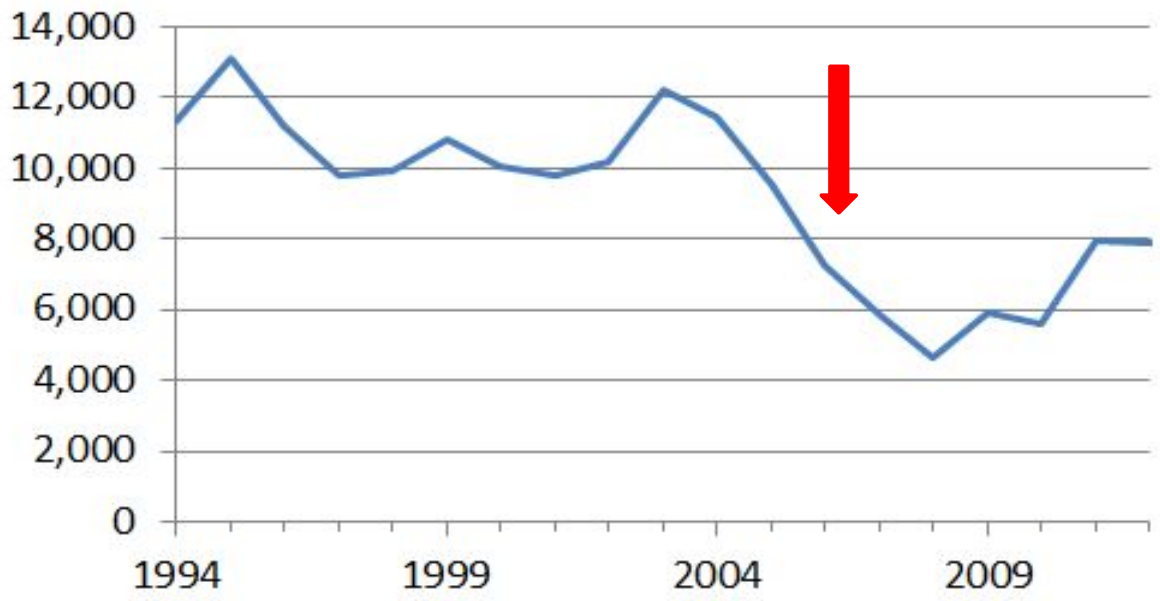


Ianelli, J.N., Barbeaux, S., Honkalehto, T., Kotwicki, S., Aydin, K. and Williamson, N., 2012. Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Bering Sea/Aleutian Islands Regions. Anchorage, AK: North Pacific Fishery Management Council; 2009.*Assessment of the walleye pollock stock in the eastern Bering Sea for*, pp.49-148.

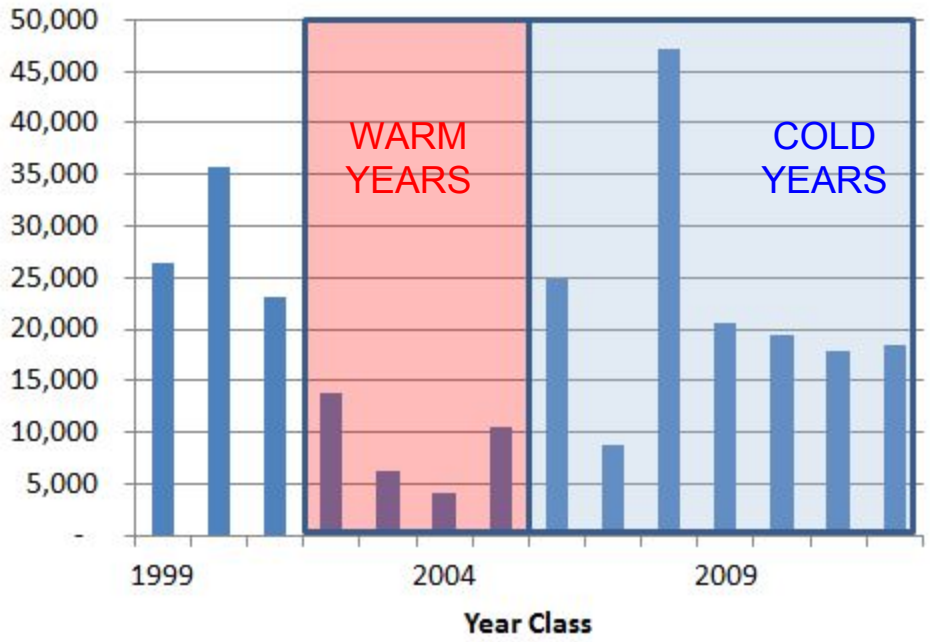
EXPLANATION:

Due to bloom timing, large crustacean zooplankton benefit from icy winters, providing prey for age-0 pollock to enter their first winter fat (and happy?)

Age-3+ Biomass (thousands t)



Age-1 number (millions)



Heintz, R.A., Siddon, E.C., Farley, E.V. and Napp, J.M., 2013. Correlation between recruitment and fall condition of age-0 pollock (Theragra chalcogramma) from the eastern Bering Sea under varying climate conditions. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, pp. 150-156.

EXPLANATION:

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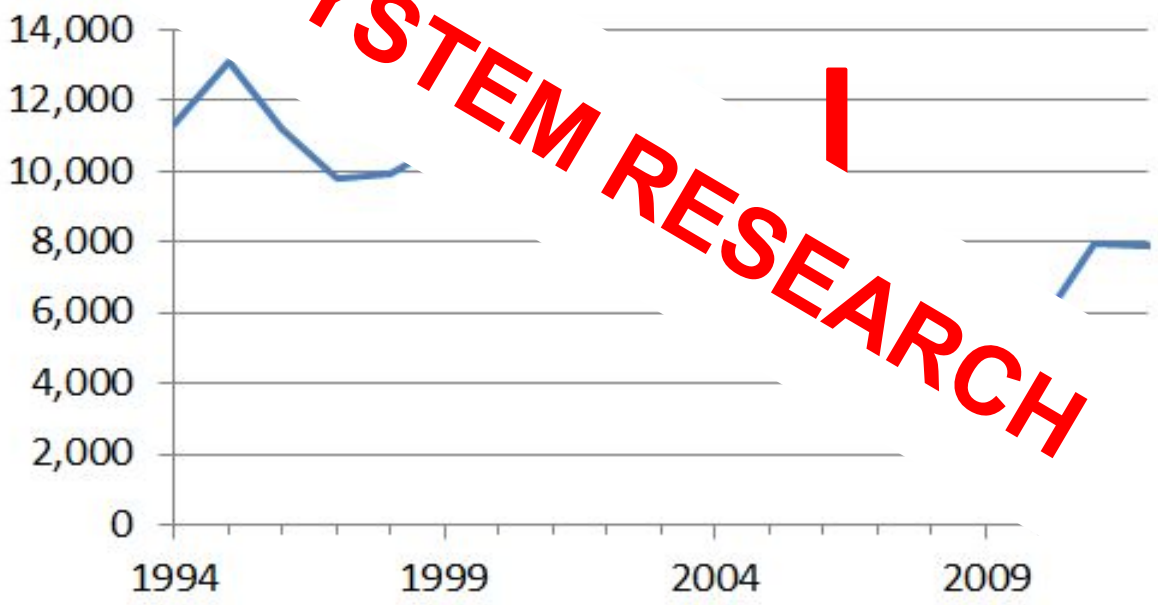

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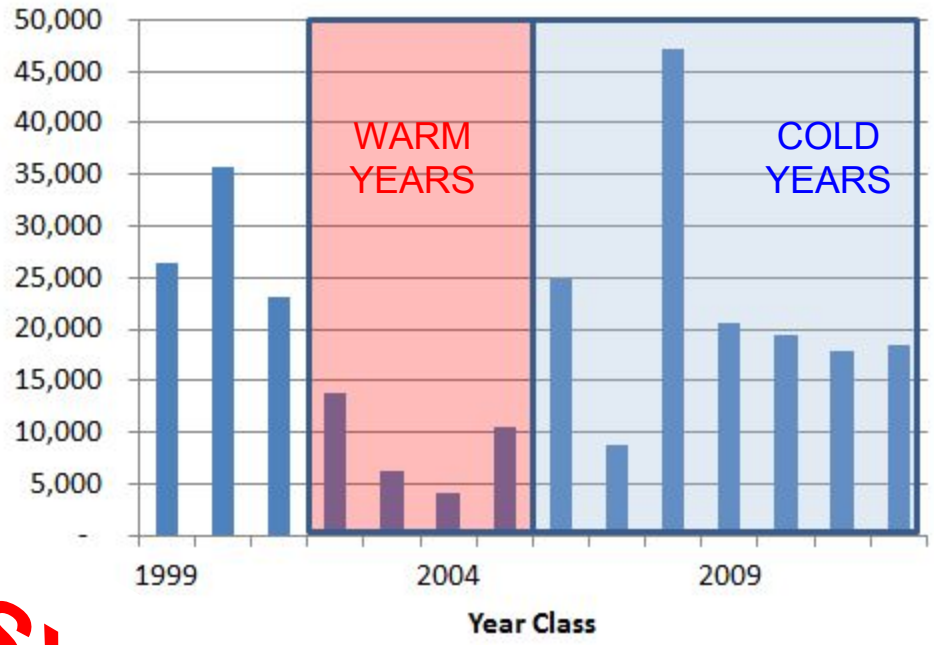

INTEGRATED ECOSYSTEM RESEARCH

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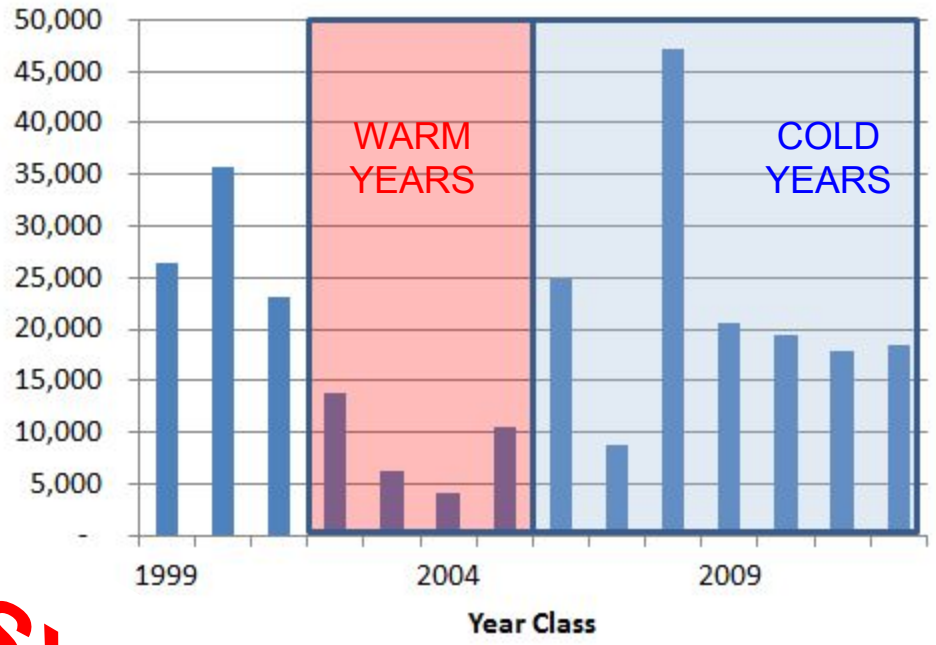

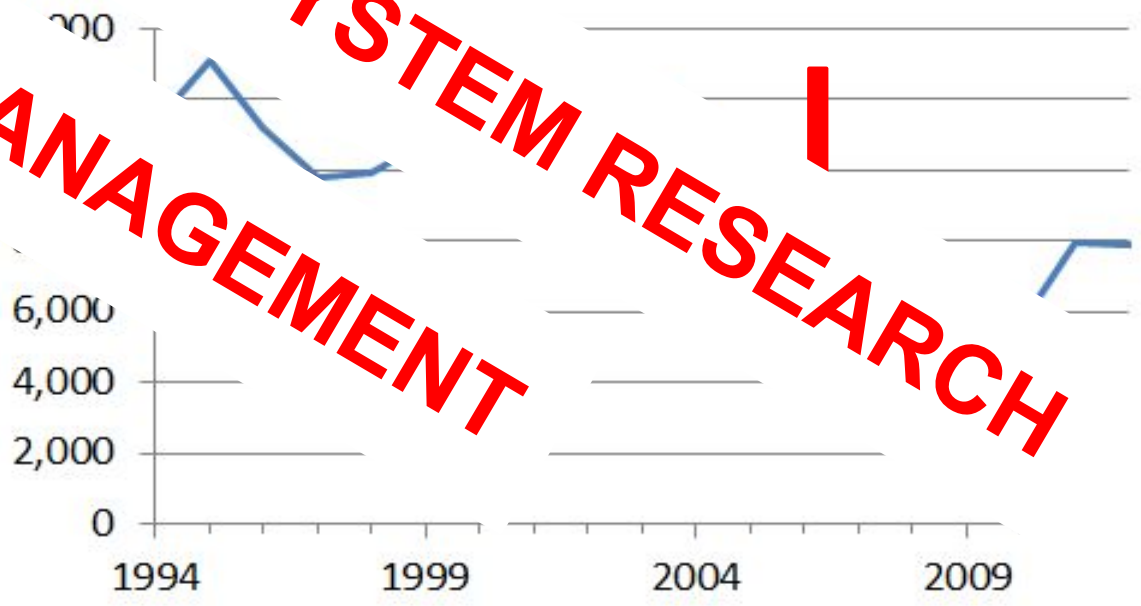

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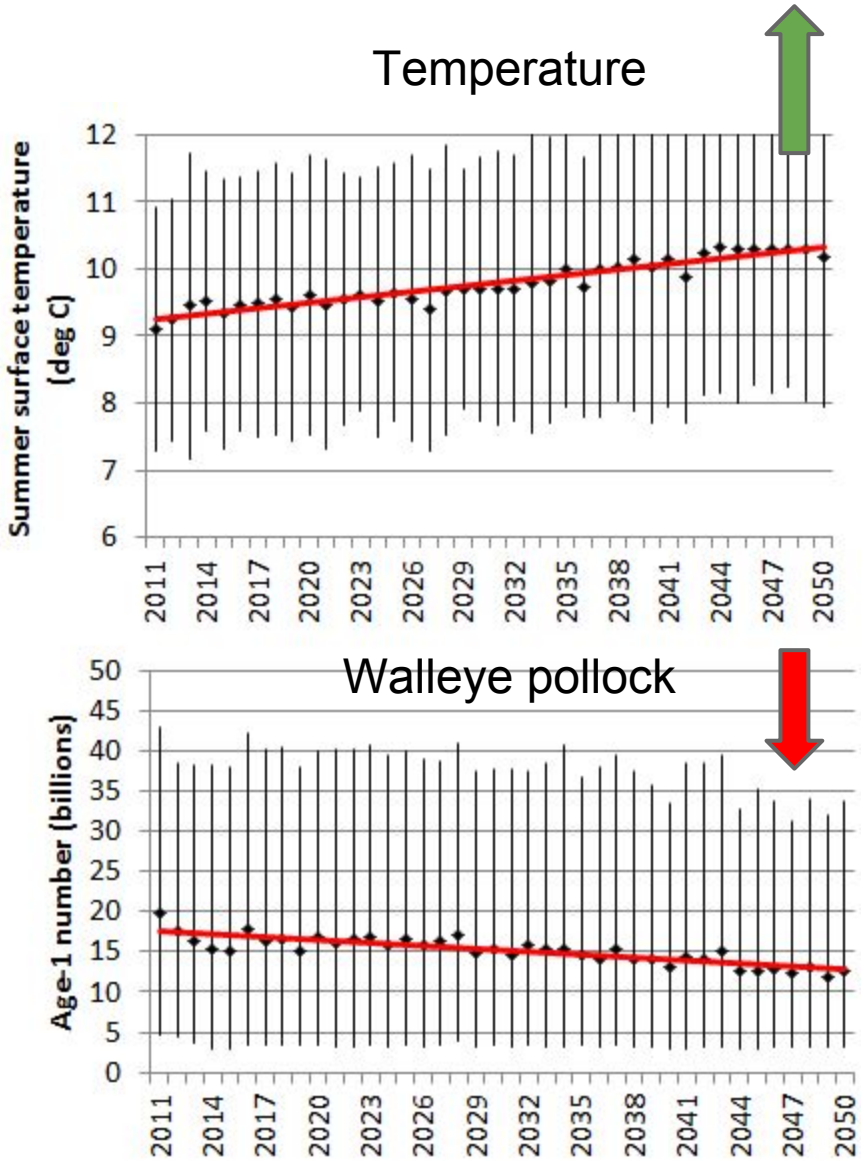
Forecast pollock abundance



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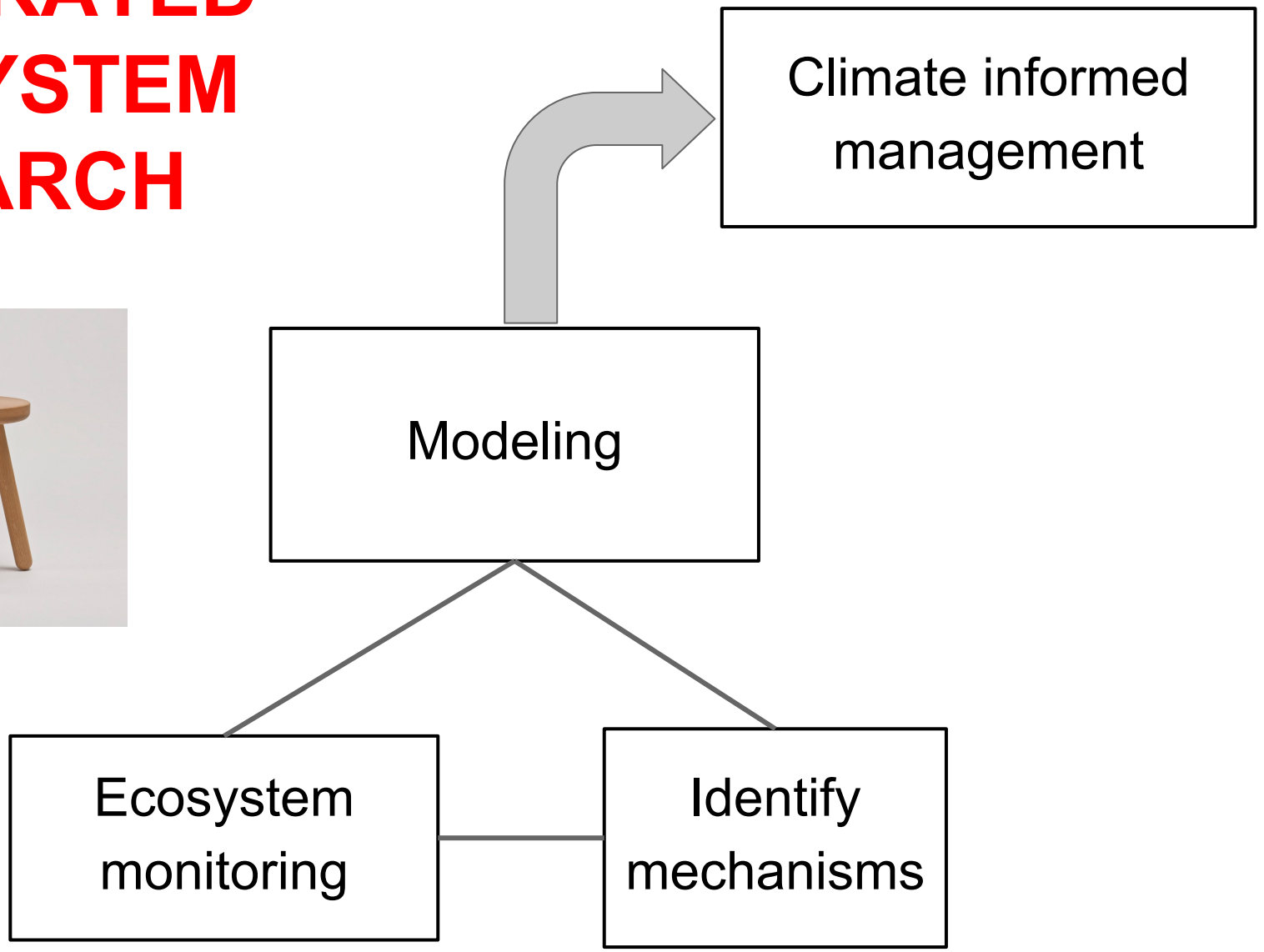
INTEGRATED ECOSYSTEM RESEARCH



Goals, objectives, prioritization, and strategy (TOR 1)

Overall strategic plan: AFSC Science Plan

Annual update: 2016 Guidance Memo

Ecosystem goals and objectives

- Recruitment Processes Alliance White Paper
- Essential Fish Habitat Research Plan
- Loss of Sea Ice Research Plan
- Alaska Ocean Acidification Research Plan

AFSC Science Plan 2.0

Organized around the following three themes:

- Monitor and assess fish, crab, and marine mammal populations, fisheries, marine ecosystems, and the associated communities that rely on these resources.
- Understand and forecast effects of climate change on marine ecosystems.
- Achieve organizational excellence in our administrative activities through innovation and the use of best practices.

Guidance memo

Funding priorities in FY16 (ecosystem-related):

(3) research on process studies related to linking recruitment of commercially important species to environmental change, including climate change;

(6) 20-year climate forecasts for commercially-important fish and shellfish populations, including the development of a Regional Action Plan to address species vulnerability to climate change;

For example, Alaska Ocean Acidification Research Plan (Sigler et al., 2015)

- Commercially important calcareous species (crab) are first priority because of their economic value and because these species are likely to suffer direct effects of reduced CaCO3 availability.
- Second priority is commercially important fish species; this research will screen for early life history effects and effects mediated by prey.
- Third priority is coldwater corals whose ecological importance includes sheltering marine organisms (e.g., rockfish), providing focal areas for foraging, and increasing the biodiversity of seafloor habitats.

Overarching objectives of AFSC climate research

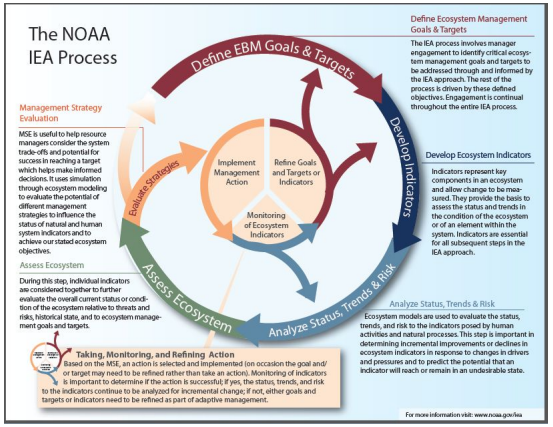
1. Understand climate impact on physics and lower trophic level species.
2. Understand how upper trophic level species are regulated by top-down (e.g., predator-prey, fishing) and bottom-up mechanisms.
3. Understand climate and ecological mechanisms sufficiently to make 20-year forecasts of fish, crab, and marine mammal abundance.

Ecosystem-based fisheries management

Six Guiding Principles outlined in the EBFM Policy Statement (NMFS 2016):

1. Implement ecosystem-level planning
2. Advance our understanding of ecosystem processes
3. Prioritize vulnerabilities and risks of ecosystems and their components
4. Explore and address trade-offs within an ecosystem
5. Incorporate ecosystem considerations into management advice
6. Maintain resilient ecosystems

Alaska IEA Program



- Delivers key products from ecosystem research to management.
- Transitions integrated ecosystem research programs to ongoing operational products.
- Strong interactive relationship with North Pacific Fisheries Management Council.
- LME-based
  - Bering Sea IEA program “maturing”
  - Gulf of Alaska IEA program “scoping and development”

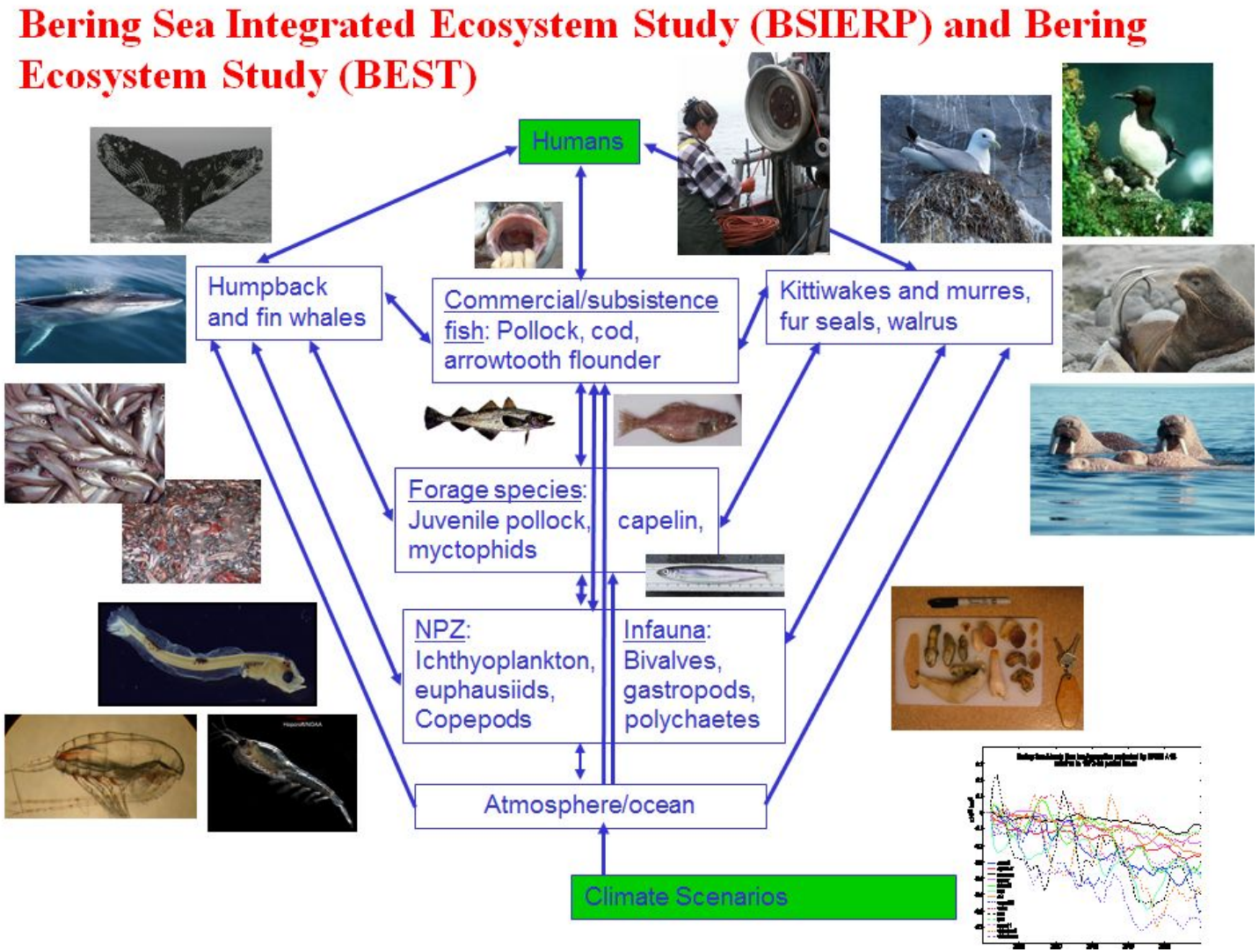
Ecosystem-related science integration (TOR 1)

- Cross-Divisional science
  - Recruitment Processes Alliance
  - Habitat and Ecological Processes Research Program

Recruitment Processes Alliance

The Recruitment Processes Alliance was formed in 2011 to grow existing collaborations on integrated ecosystem research and recruitment processes research

2007-2014



Recruitment Processes Alliance

- Formed in 2011 to grow existing collaborations on integrated ecosystem research and recruitment processes research
- Encompasses 7 Alaska Fisheries Science Center and Pacific Marine Environmental Laboratory research programs

Encompasses 7 AFSC and PMEL programs

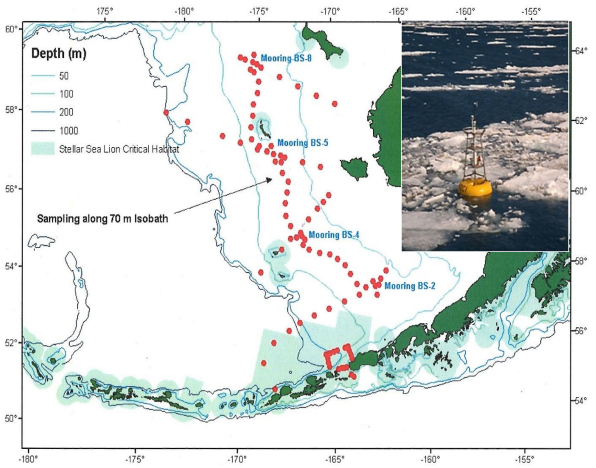
Program	Description	Lead
PMEL Ocean Environment Research (FOCI)	Oceanography	Stabeno
Recruitment Processes (FOCI)	Fisheries oceanography	Duffy-Anderson
Ecosystem Monitoring and Assessment	Fisheries oceanography	Farley
Resource Energetics and Coastal Assessment	Bioenergetics	Heintz
Status of Stocks and Multispecies Assessment	Stock assessments	Hollowed
Marine Ecology and Stock Assessment	Stock assessments	Heifetz
Resource Ecology and Ecosystem Modeling	Ecosystem modeling	Aydin

Hypotheses

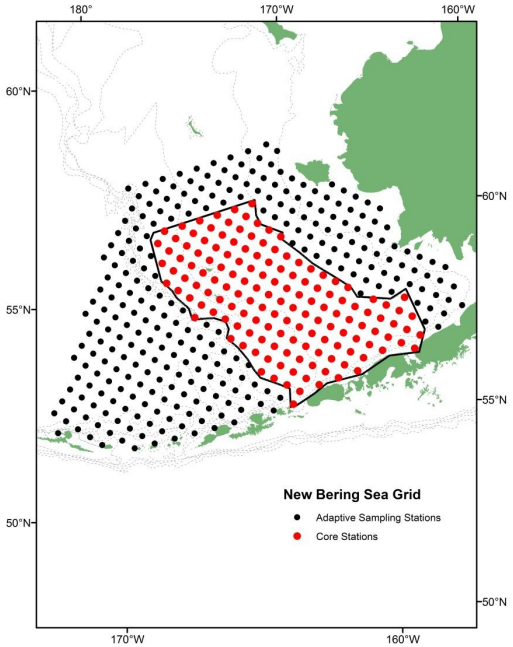
- H_o: Climate change and variability have predictable effects on the bottom-up and top-down mechanisms which regulate fisheries recruitment in Alaska.
- H_o: The effects of climate and ecosystem function on fish recruitment are most evident during two critical periods: 1) the early to late larval stage when mortality is a function of growth rate, and 2) the first winter when mortality is a function of size and energetic status obtained during the previous summer and fall.

Seasonal surveys

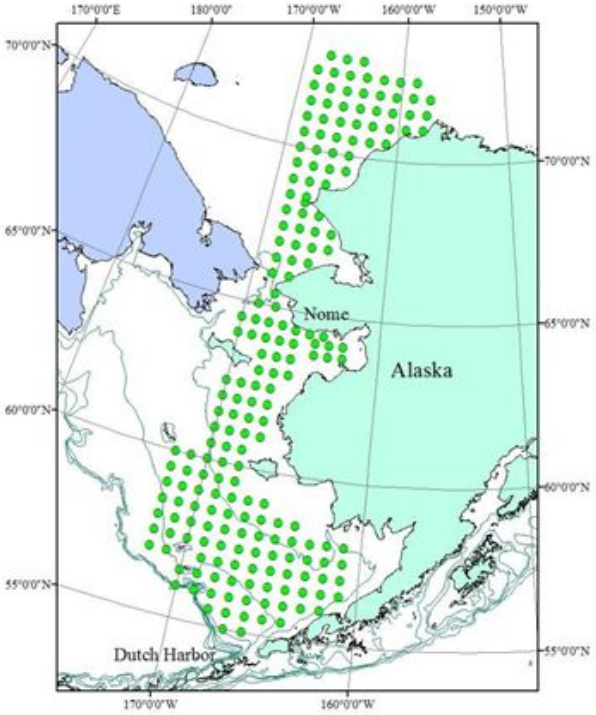
April-May & Sept-Oct physics



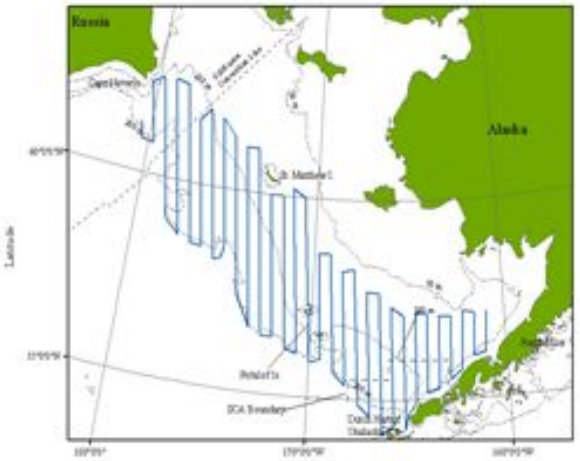
May, larval



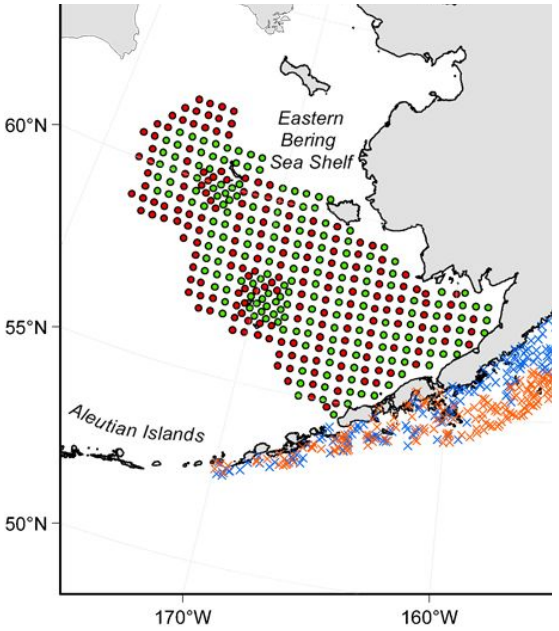
August-September, age-0



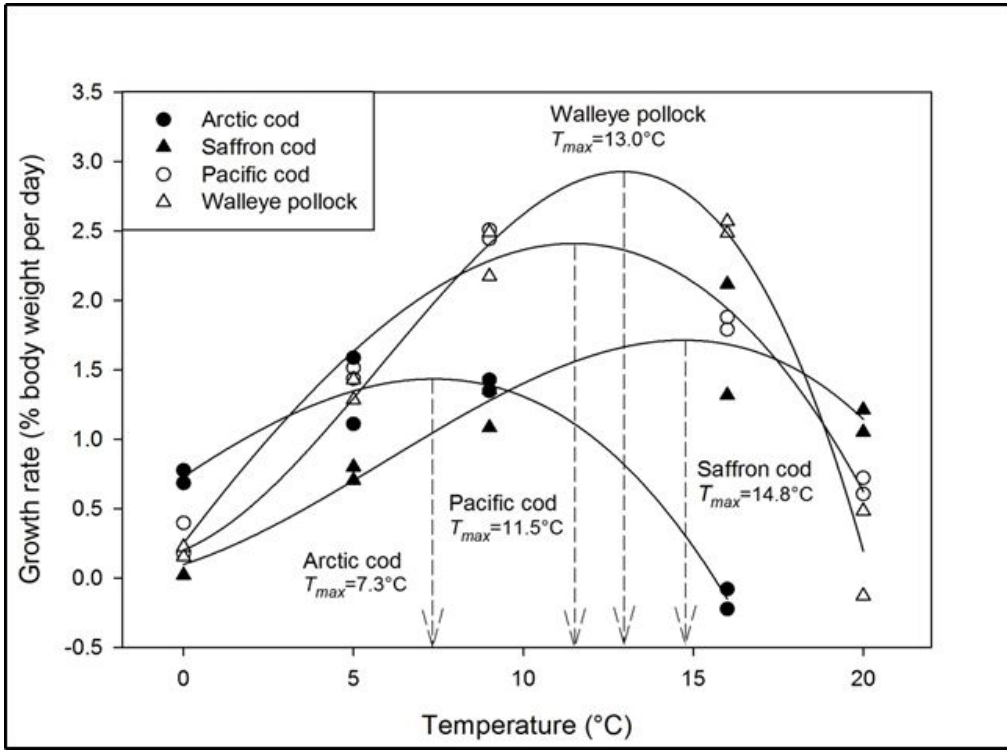
June-July, age-1



June-July, age-3+



Laboratory analyses and experiments

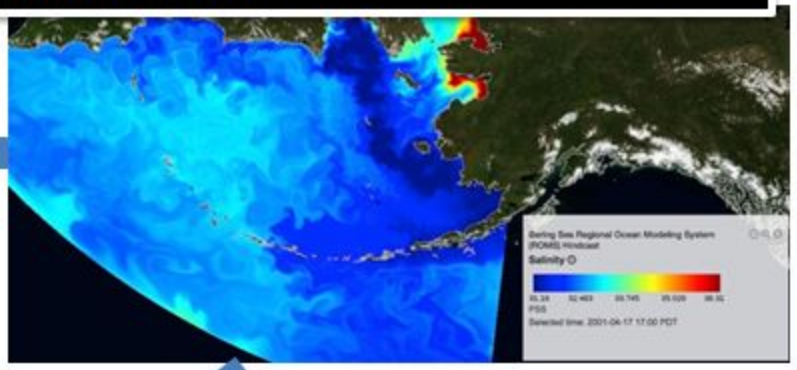


Laurel et al in review

Models

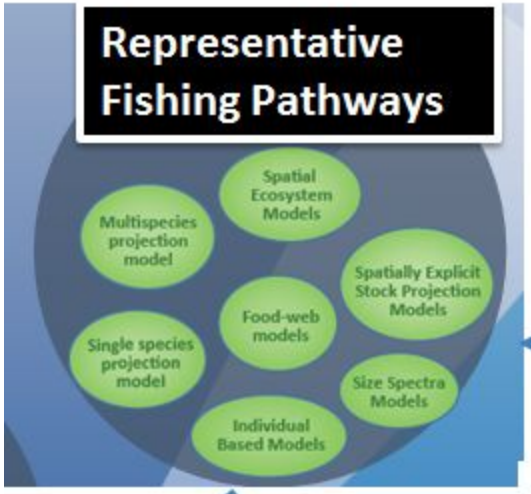
GFDL ESM

Bering Sea – high resolution Regional Ocean Model

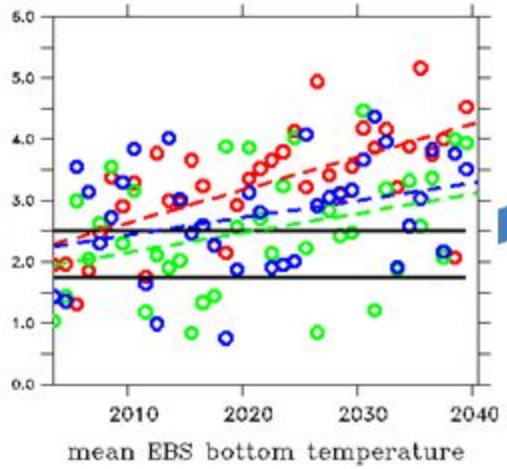


FEAST – Coupled end-to-end Model

Representative Fishing Pathways

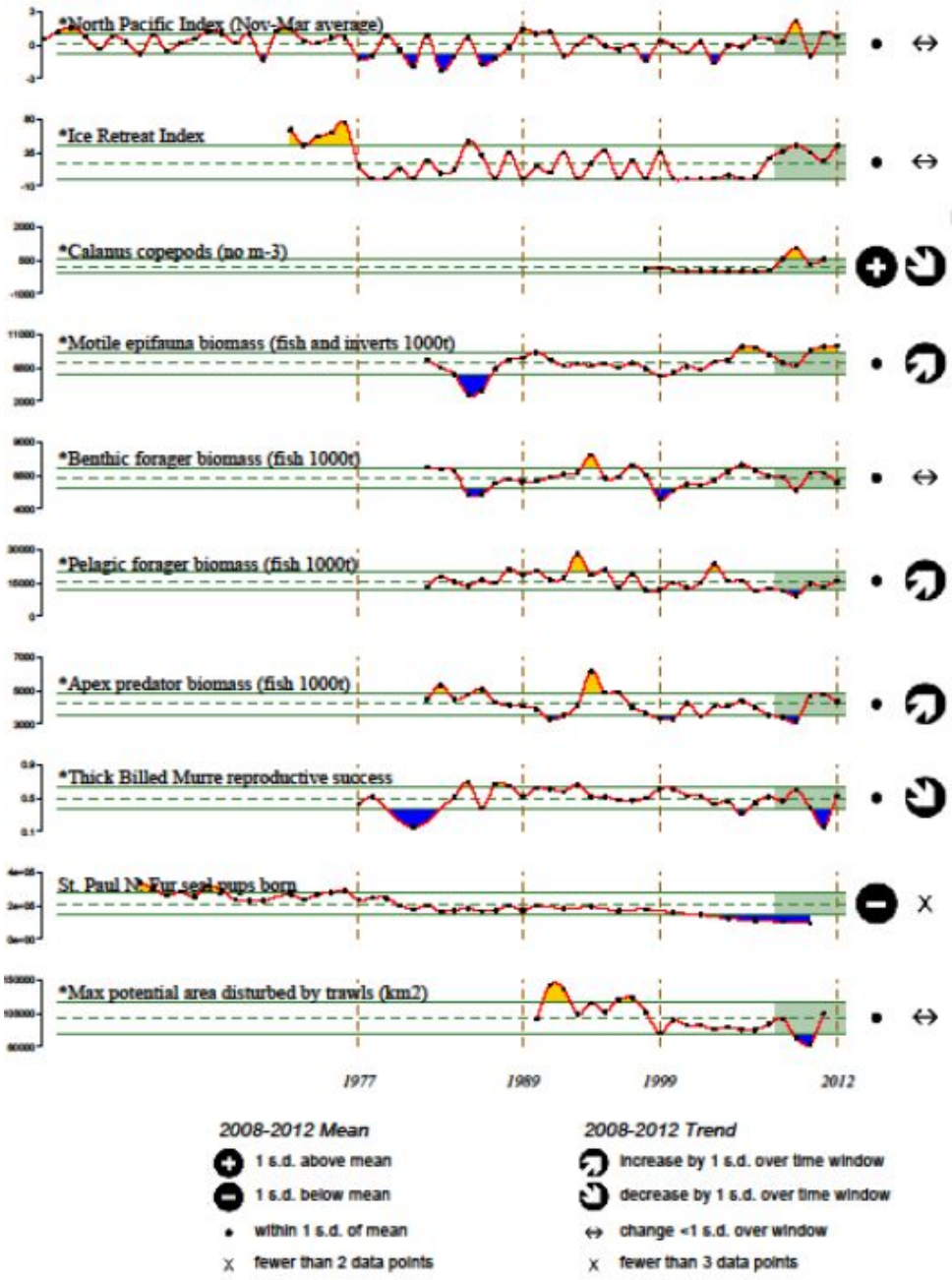


Ecosystem models

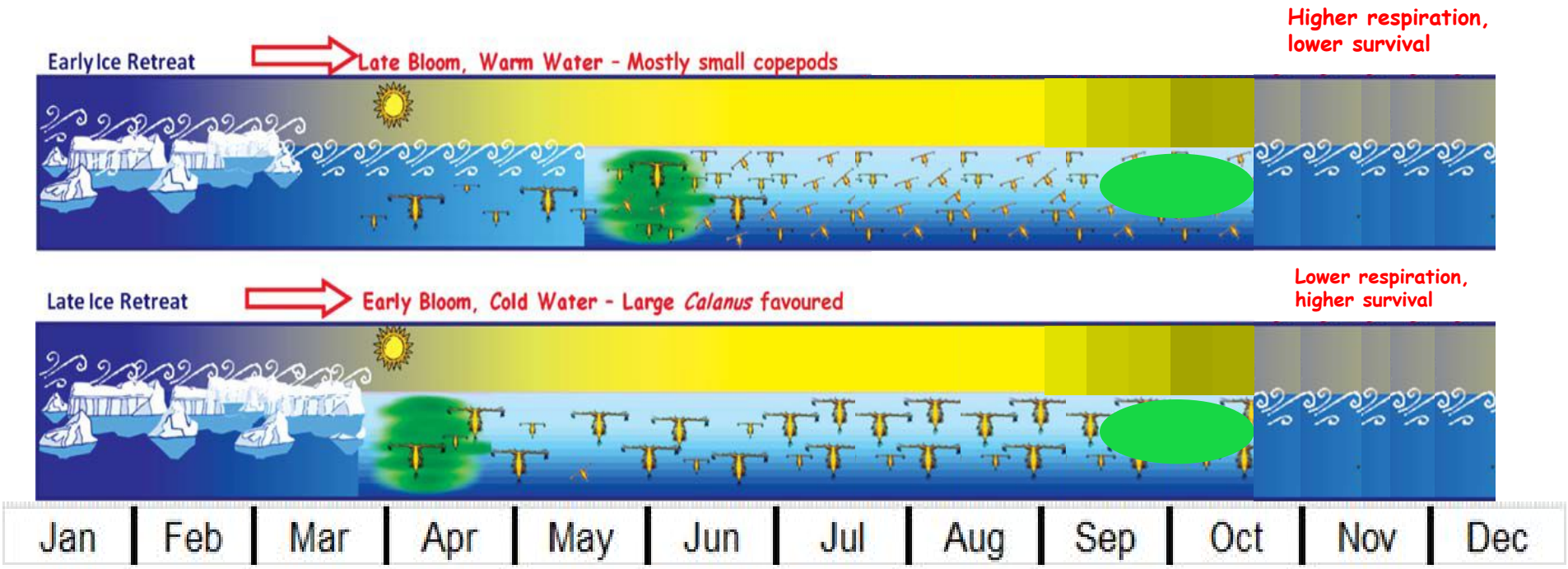


Stock Projection Models

Products: Ecosystem report cards



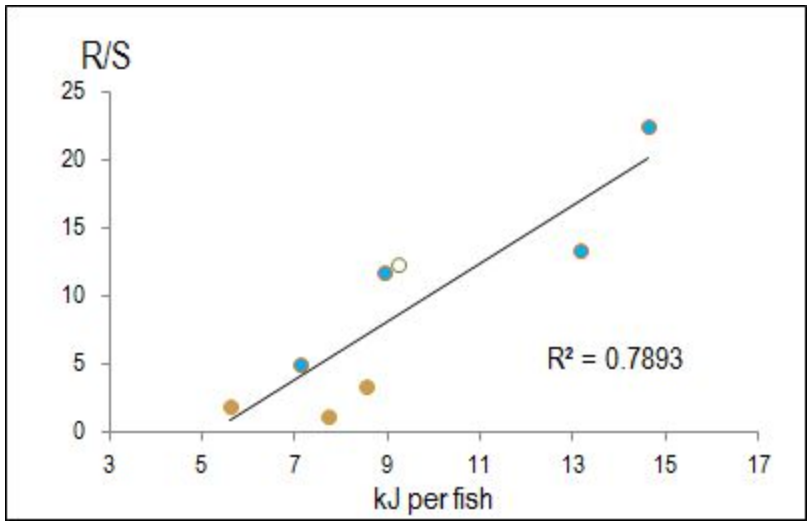
Products: Mechanisms affecting pollock recruitment



Hunt et al 2011, Sigler et al 2016

Age-0 pollock in late summer

Heintz et al 2013



Habitat and Ecological Processes Research Program

- The HEPR Program focuses on integrated studies that combine scientific capabilities and create comprehensive research on habitat and ecological processes.
- Teams of AFSC and Pacific Marine Environmental Laboratory (PMEL) scientists collaborate in new research, proactively identify emerging management issues and draw expertise from fishery, habitat, and protected resource managers at the Alaska Regional Office.

Habitat and Ecological Processes Research Program

- Loss of Sea Ice
- Essential Fish Habitat
- Ocean Acidification
- Bering Sea Project

Loss of Sea Ice

Northern Bering Sea bottom trawl surveys

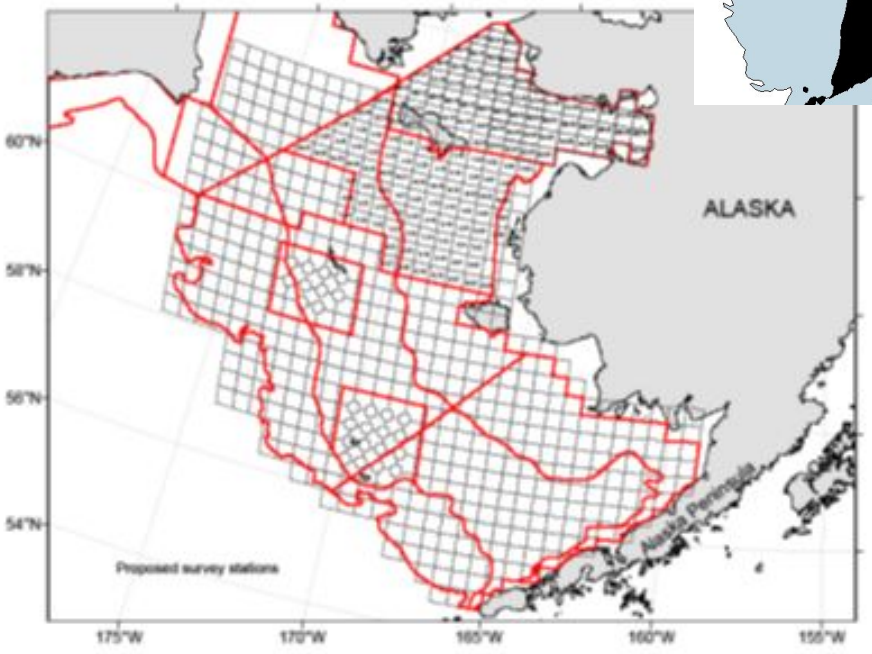
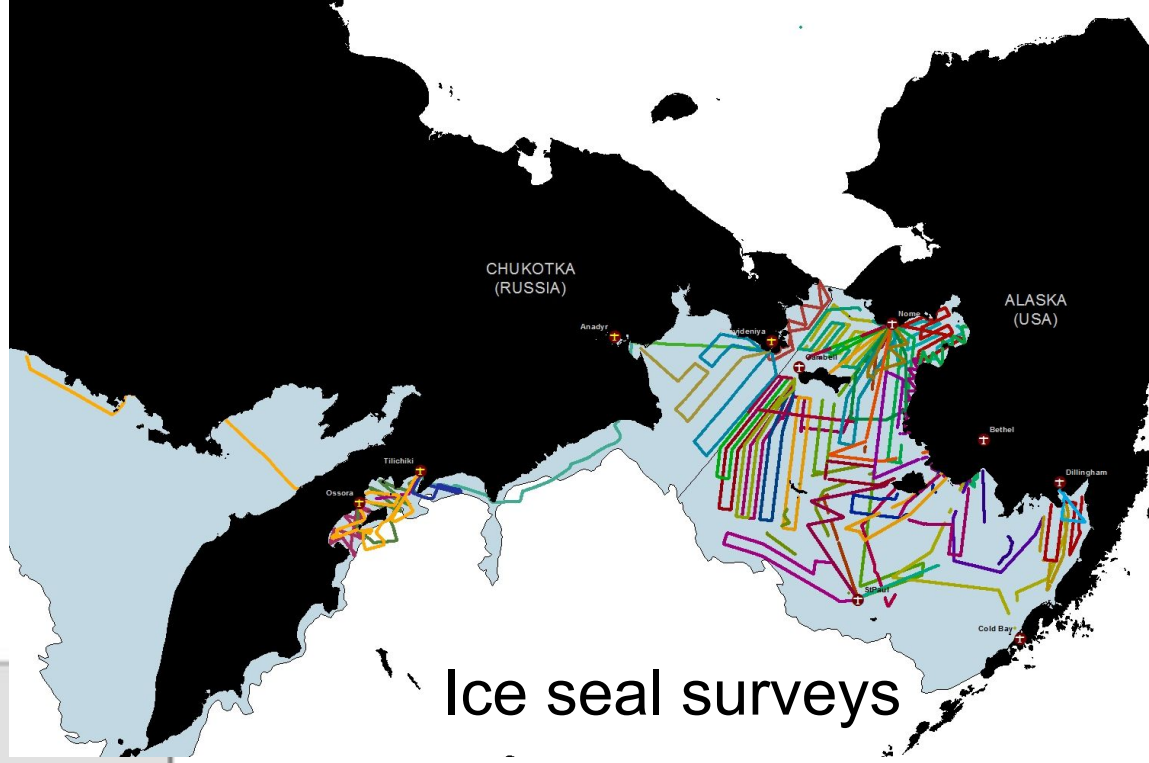


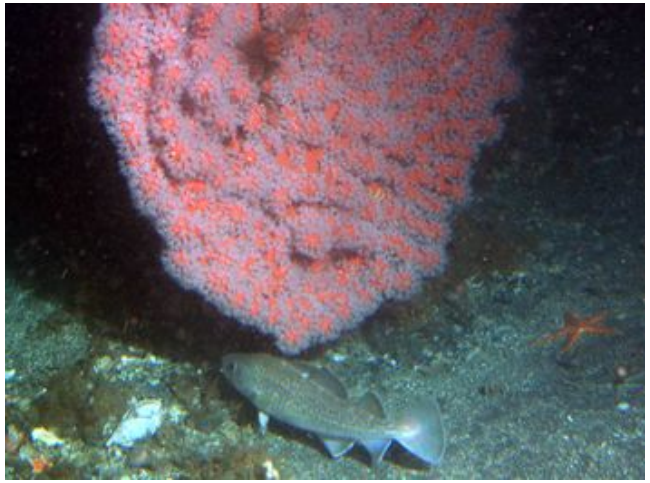
Figure 1. – Grid map of proposed northern stations for the expanded 2010 eastern Bering Sea continental shelf bottom trawl survey.



Ice seal surveys

[Loss of Sea Ice Research Plan]

Essential Fish Habitat



- Annual RFP
- Science panel review
- Management prioritization by habitat managers (Alaska Regional Office)
- $400K-$500K is spent on up to ten EFH research projects each year
- $5M spent, 70 projects, 75 publications since 2005

Essential Fish Habitat Research Plan

Climate science strategy regional action plan (TOR 3)

NOAA FISHERIES

Alaska Fisheries Science Center

Climate Science Regional Action Plan

Southeastern Bering Sea

Mike Sigler, Alan Haynie, Amber Himes-Cornell, Anne Hollowed, Phil Mundy, Phyllis Stabeno, Stephani Zador, Steve Davis, Brandee Gerke

NOAA FISHERIES

NOAA Fisheries Climate Science Strategy

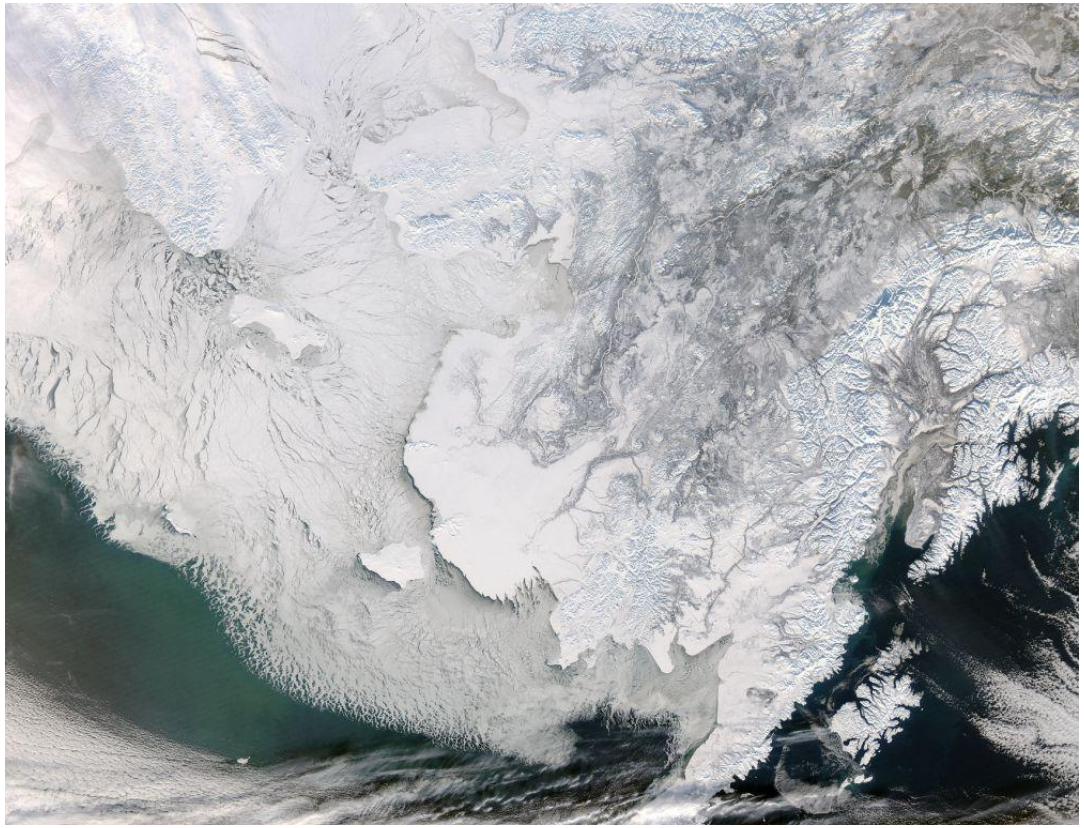
Highlights

Regional Action Plan for Southeastern Bering Sea Climate Science

Assessment

Action Plan

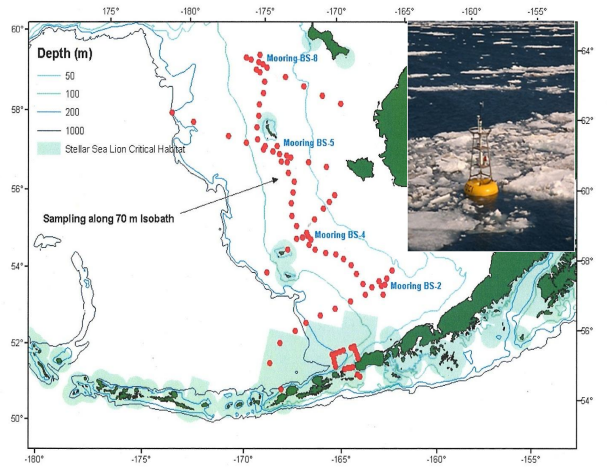
Public review version



Monitor ecosystems

Seasonal surveys

April-May & Sept-Oct physics



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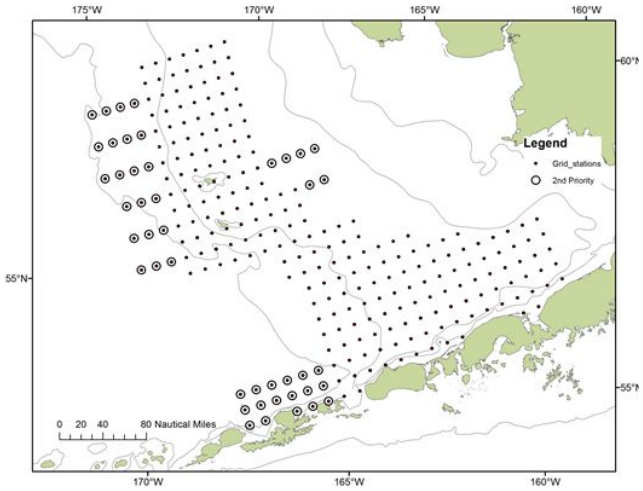
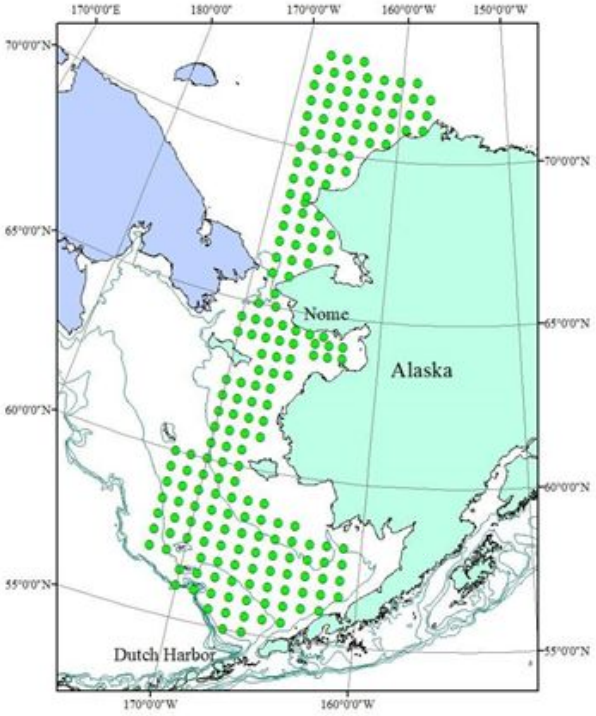


August-September, age-0



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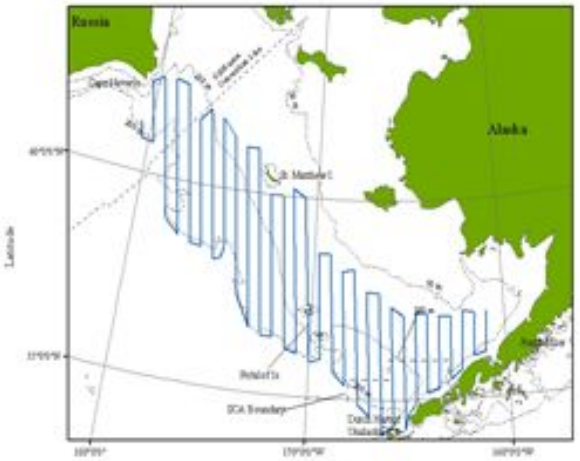

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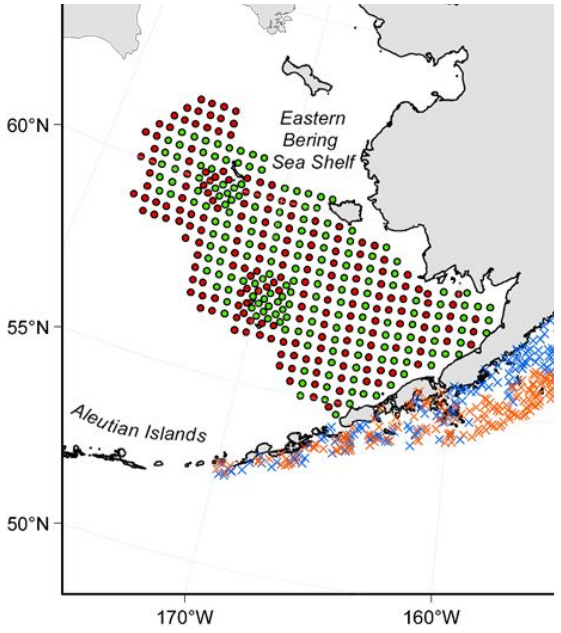
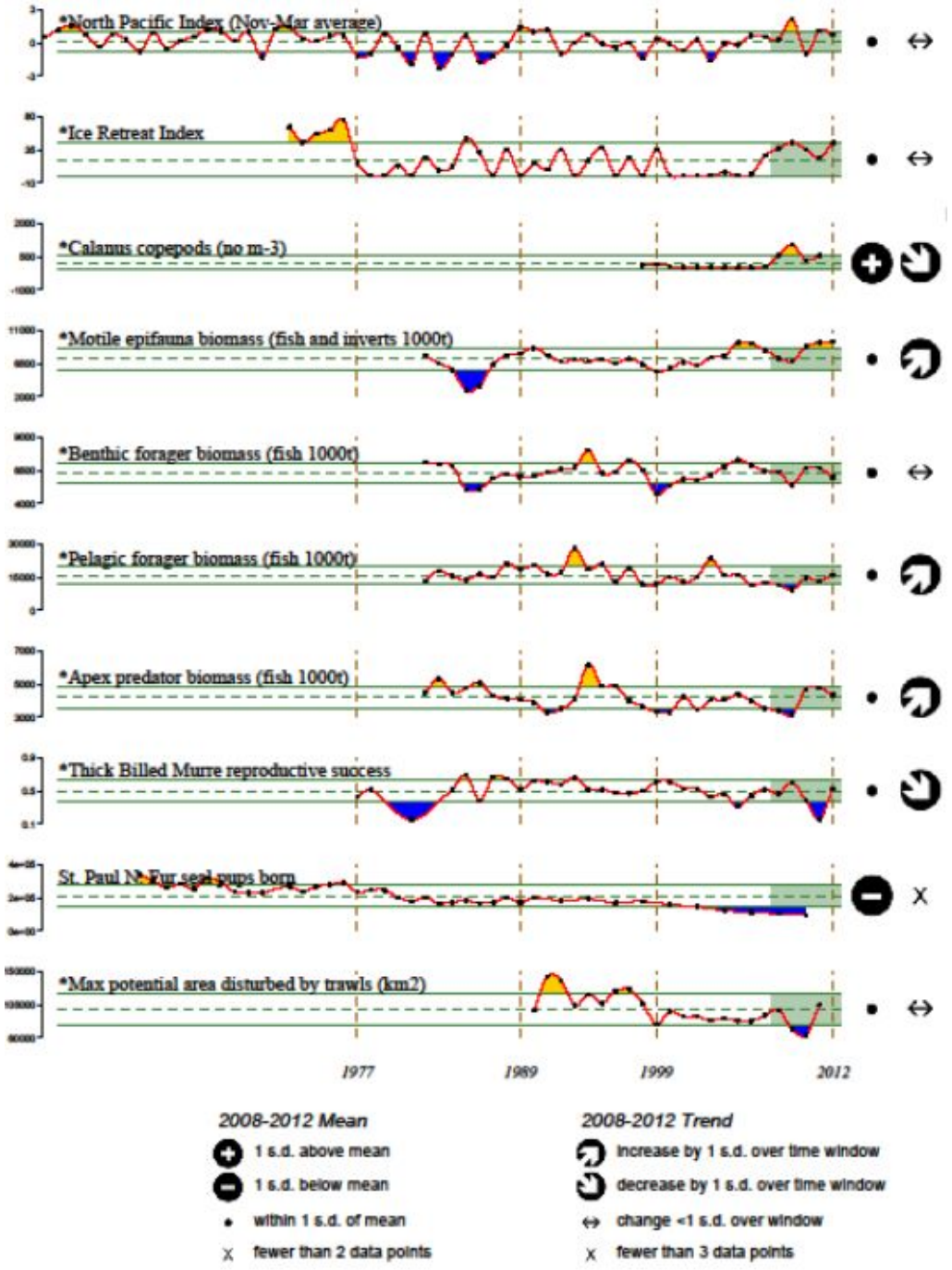
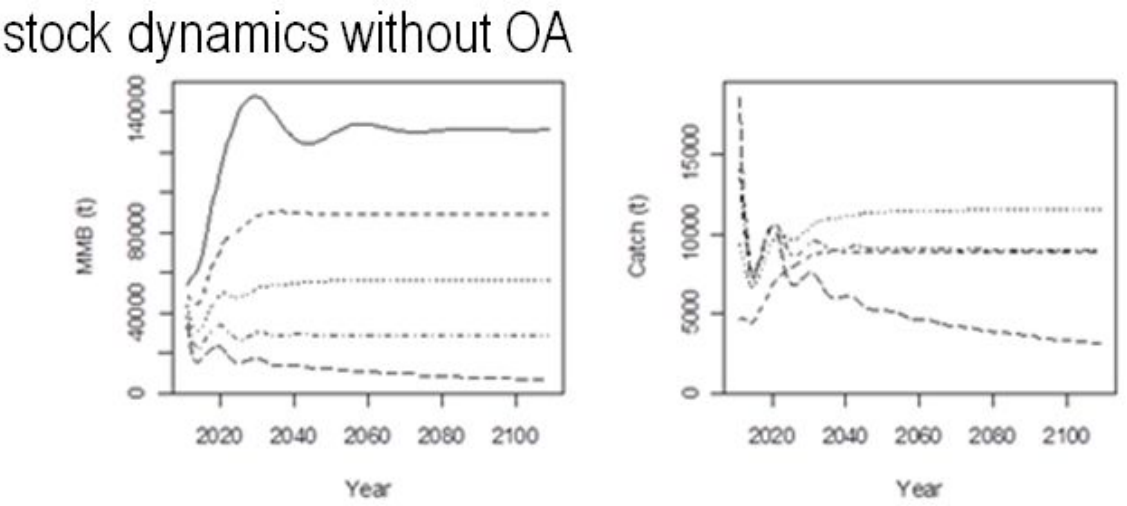


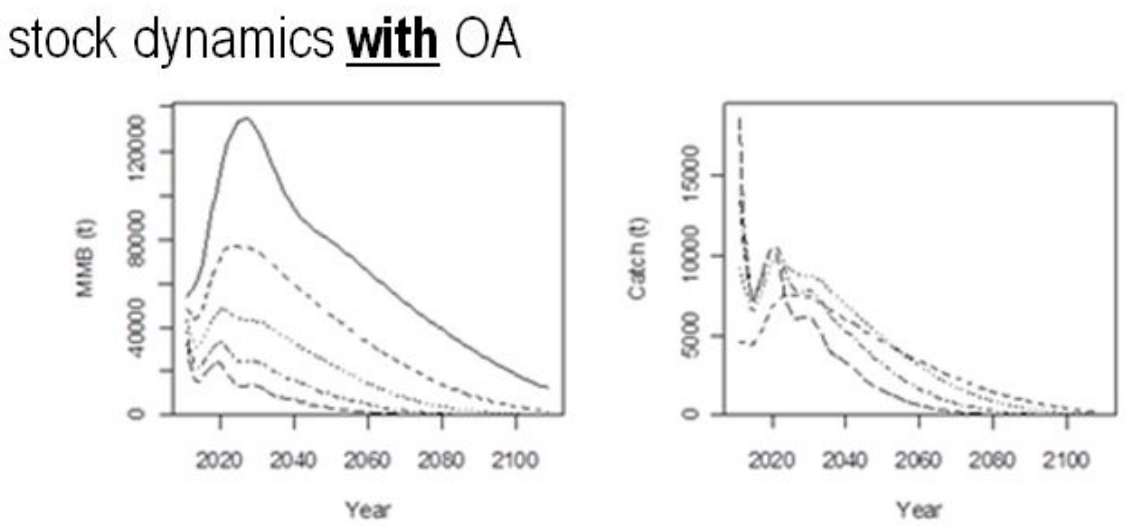
Alaska Marine Ecosystem Considerations



Identify mechanisms (process studies)

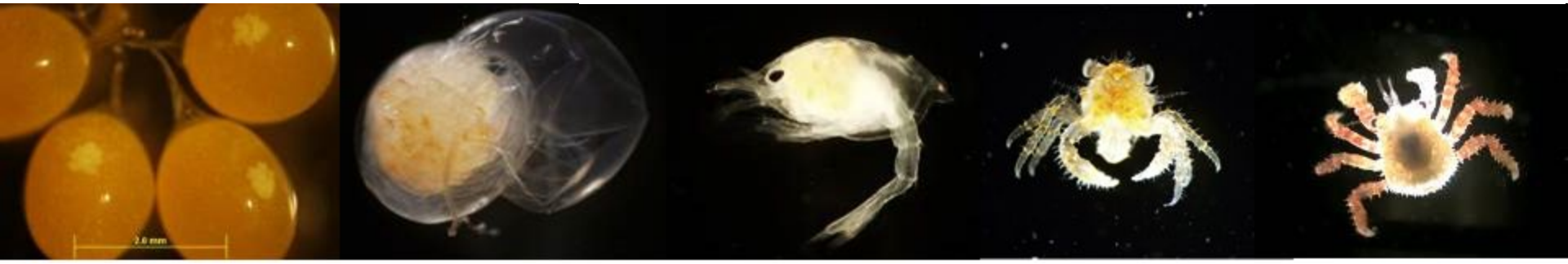
Ocean acidification research





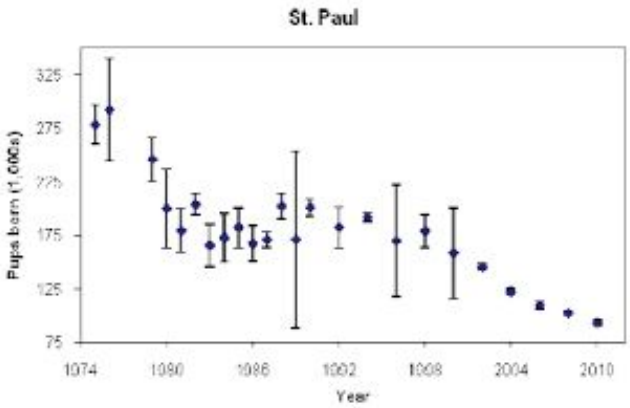
Long, W.C., Swiney, K.M. and Foy, R.J., 2013. Effects of ocean acidification on the embryos and larvae of red king crab, Paralithodes camtschaticus.*Marine pollution bulletin*, *69*(1), pp. 38-47.

Punt, Poljak, Dalton, Foy. 2014. Evaluating the impact of ocean acidification on fishery yields and profits: The example of red king crab in Bristol Bay. Ecol. Modeling. 285: 39-53.



Fur seal research

- Pup production on the Pribilof Islands decreased by approximately 45% since 1998. Cause unknown, but may include direct and indirect effects of fishery competition as well as climate.
- Satellite telemetry from 1992 to 2016 is being used to understand effects during the winter migration and summer foraging.
- This project will link fine-scale changes in fur seal foraging behavior with measures of pollock distribution and abundance in real time.

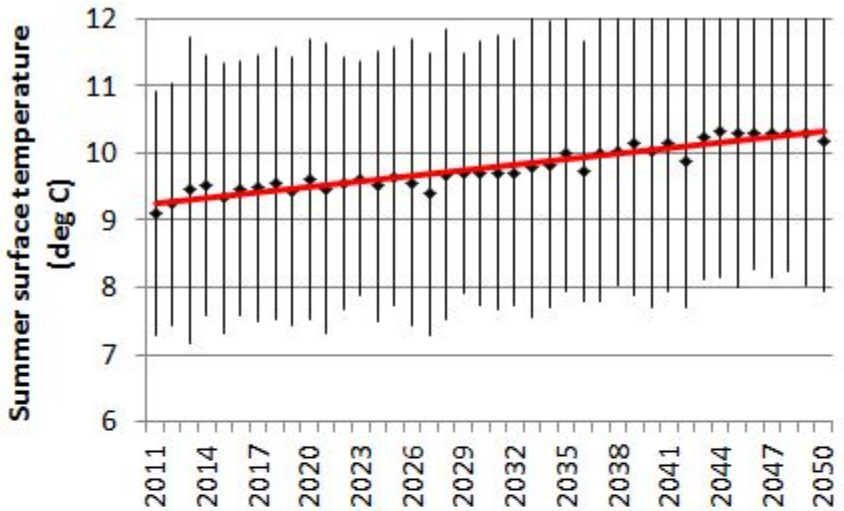


Allen, B.M., Angliss, R.P. and Wade, P. R., 2011. *Alaska marine mammal stock assessments, 2010*.

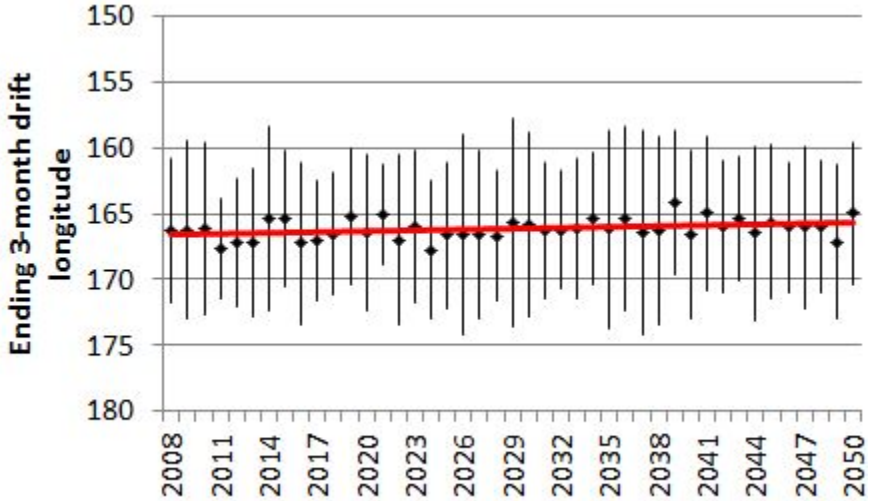
Modeling:
Forecast models and management strategy evaluations (MSE)

Ocean model projections

Temperature



Inshore transport



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Wilderbuer, T., Stockhausen, W. and Bond, N., 2013. Updated analysis of flatfish recruitment response to climate variability and ocean conditions in the Eastern Bering Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, pp.157-164.

NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Alaska CLIMate Project

Anne Hollowed (AFSC, SSMA/REFM)
Kirstin Holsman (AFSC, REEM/REFM)
Alan Haynie (AFSC ESSR/REFM)
Stephen Kasperski (AFSC ESSR/REFM)
Jim Ianelli (AFSC, SSMA/REFM)
Kerim Aydin (AFSC, REEM/REFM)
Trond Kristiansen (IMR, Norway)
Al Hermann (UW JISAO/PMEL)
Wei Cheng (UW JISAO/PMEL)
André Punt (UW SAFS)

FATE: Fisheries & the Environment
SAAM: Stock Assessment Analytical Methods
S&T: Climate Regimes & Ecosystem Productivity

IPCC Scenarios (x3)

AR4 A1B
AR5 RCP 4.5
AR5 RCP 8.5

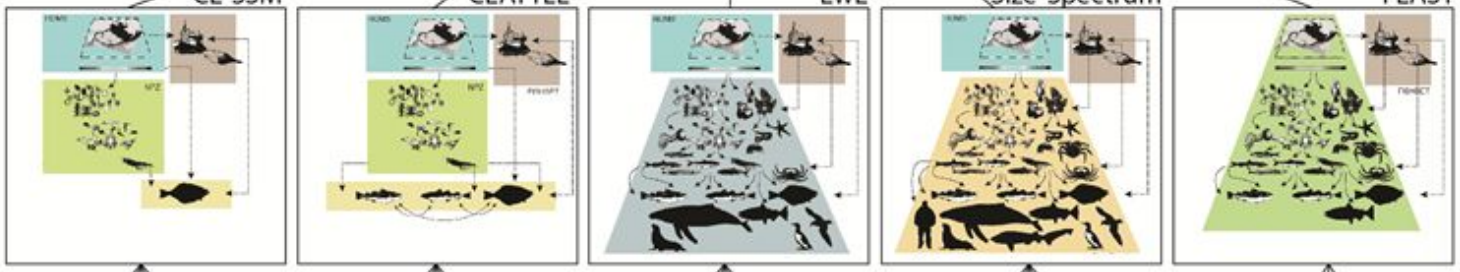
Global Climate Models (x 11)

ECHO-G (AR4 A1B)
MIROC3.2 med res. (AR4 A1B)
CGCM3-t47 (AR4 A1B)
CCSM4-NCAR- PO (AR5 RCP 4.5 & 8.5)
MIROCESM-C- PO (AR5 RCP 4.5 & 8.5)
GFDL-ESM2M*- PO (AR5 RCP 4.5 & 8.5)
GFDL-ESM2M*- PON (AR5 RCP 4.5 & 8.5)

Future Climate Scenarios

Bering Sea Models

CE-SSM | CEATTLE | EwE | Size-Spectrum | FEAST



By-catch, MSY
Status quo, MEY, No fishing
Harvest Control Rules (x5)

By-catch, MSY
Status quo, MEY, No fishing
Harvest Control Rules (x5)

By-catch, MSY
Status quo, MEY, No fishing
Harvest Control Rules (x5)

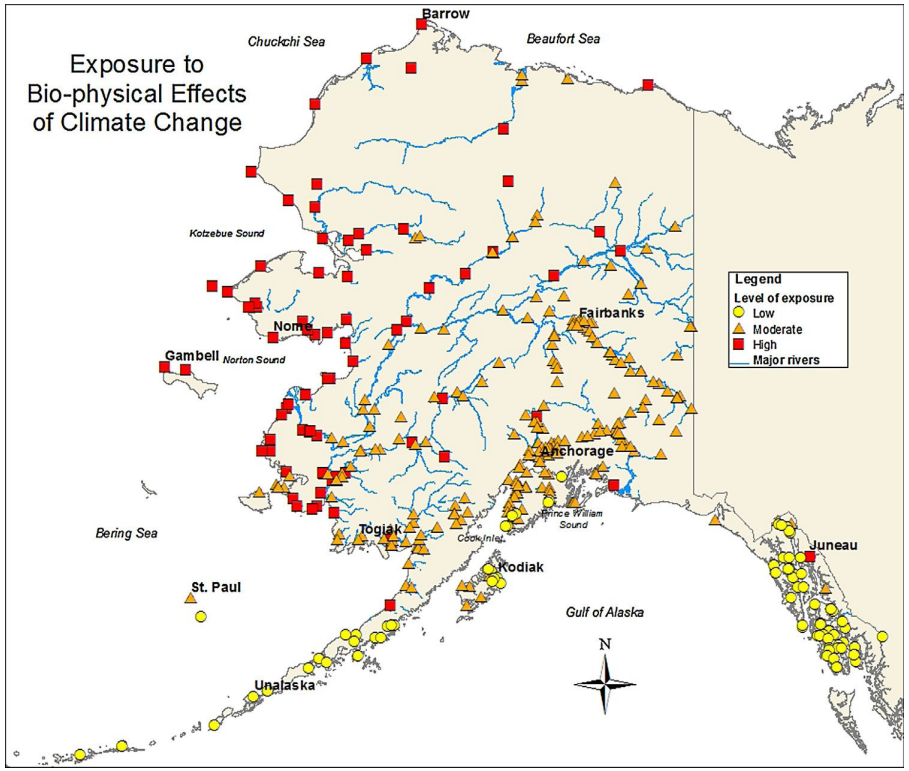
By-catch, MSY
Status quo, MEY, No fishing
Harvest Control Rules (x5)

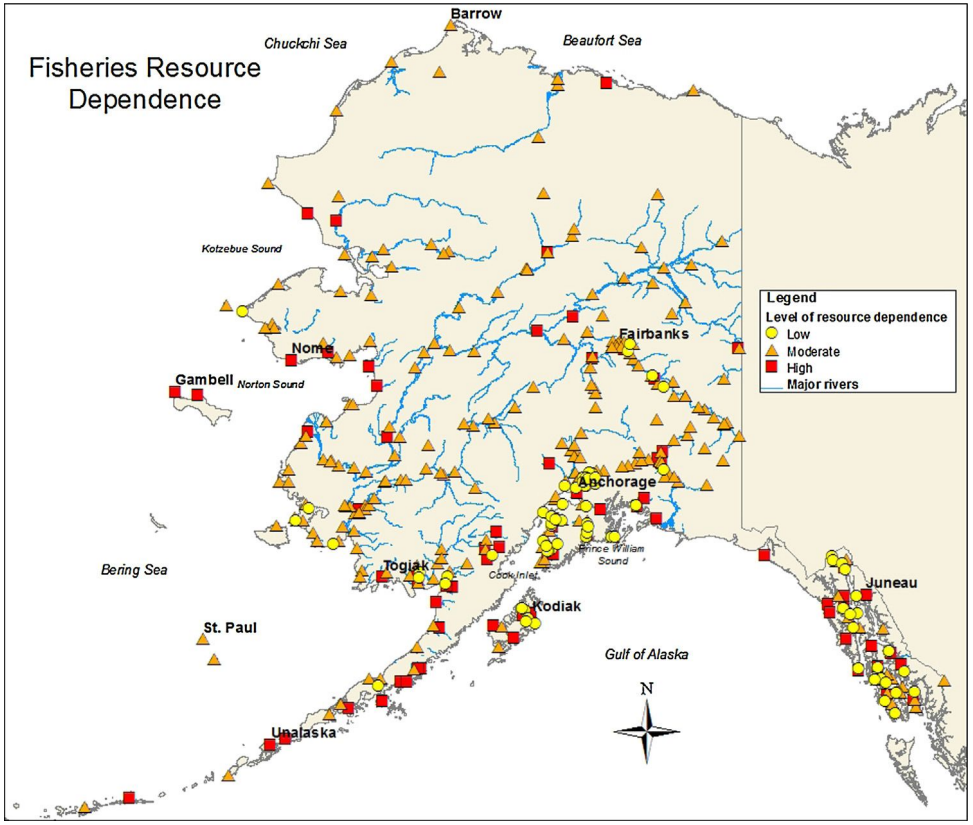
Fleet dynamics
Status quo, No fishing
Harvest Control Rules (x3)

Climate-enhanced Biological Models

Fishing Scenarios

Identify human community dependence on LMRs and effects of climate change.





Himes-Cornell, A. and Kasperski, S., 2015. Assessing climate change vulnerability in Alaska's fishing communities. *Fisheries Research*, *162*, pp.1-11.

NPFMC Fisheries Ecosystem Plan. Approved by the Council in December 2015, the FEP includes a climate module that would:

1) synthesize current climate change project outcomes;
2) prioritize species for MSE evaluation; and
3) run MSEs on specific species and scenarios identified by the Council.

Challenge 1

Our ability to project future impacts is limited by our understanding of ecological processes. Understanding is sufficient for **only 3 of 21** comprehensively assessed stocks in the southeastern Bering Sea.

- Walleye pollock (through loss of sea ice) 
- Red king crab (through increased CO2) 
- Northern rock sole 

Mueter, F.J., Bond, N.A., Ianelli, J.N. and Hollowed, A.B., 2011. Expected declines in recruitment of walleye pollock (Theragra chalcogramma) in the eastern Bering Sea under future climate change. *ICES Journal of Marine Science: Journal du Conseil*, p. fsr022.

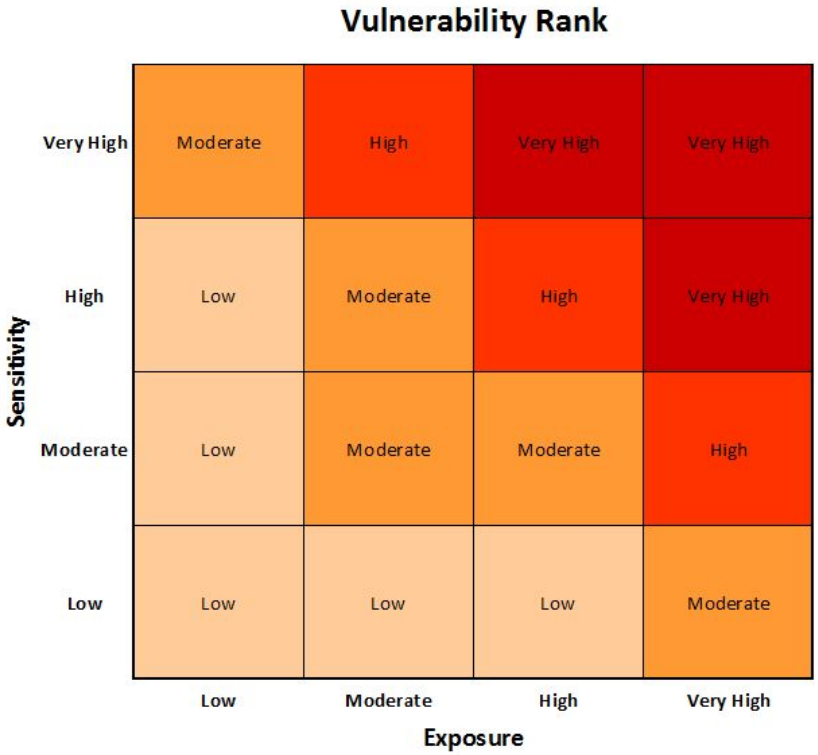
Wilderbuer, T., Stockhausen, W. and Bond, N., 2013. Updated analysis of flatfish recruitment response to climate variability and ocean conditions in the Eastern Bering Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, *94*, pp.157-164.

Long, W.C., Swiney, K.M. and Foy, R.J., 2013. Effects of ocean acidification on the embryos and larvae of red king crab, Paralithodes camtschaticus.*Marine pollution bulletin*, *69*(1), pp.38-47.

Punt, Poljak, Dalton, Foy. 2014. Evaluating the impact of ocean acidification on fishery yields and profits: The example of red king crab in Bristol Bay. Ecol. Modeling. 285: 39-53.

Climate vulnerability assessment

A climate vulnerability assessment for the southeastern Bering Sea, which will **qualitatively assess** species vulnerabilities to climate change and provide guidance on research prioritization, currently is underway. The vulnerability assessment uses expert elicitation methods to quantify a species' exposure and sensitivity to expected climate change.



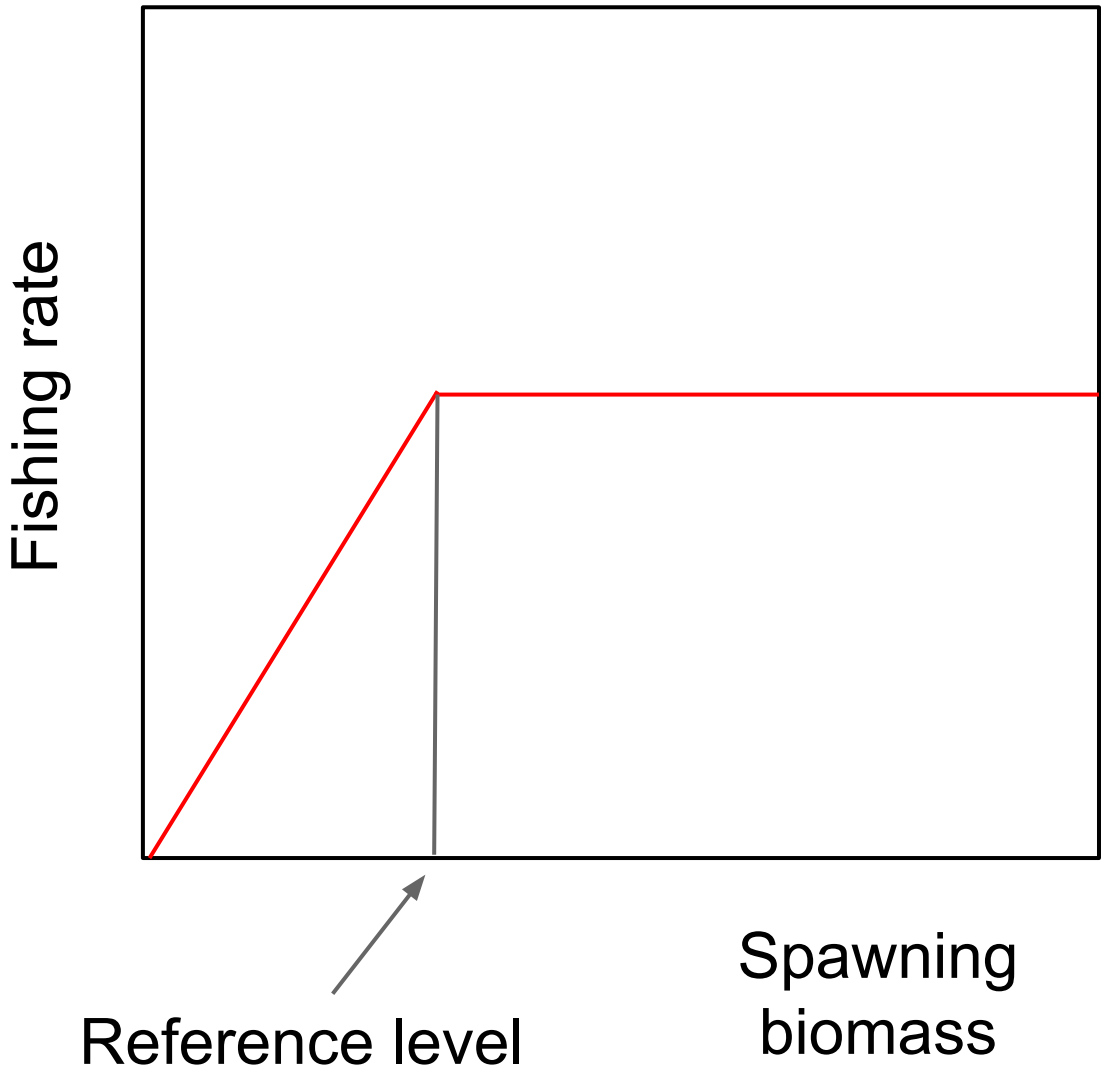
Spencer, Hollowed, Nelson, Sigler, In prep.. *Climate Vulnerability Assessment for the southeastern Bering Sea.*.

Recruitment Processes Alliance

- Research is conducted to understand processes affecting recruitment strength, including effects of climate.
- To date, understanding of these ecological mechanisms sufficient only to quantify effects on 3 fisheries (pollock, red king crab, northern rock sole).
- A significant fraction of AFSC resources are invested in this effort (e.g., ~15% of labor).

Challenge 2 (Obj. 3)

The NPFMC currently has a process that adapts harvest actions to changing measurements from fishery independent surveys. What is not well worked out is how and when the North Pacific Fishery Management Council should react to climate-induced reference point changes.

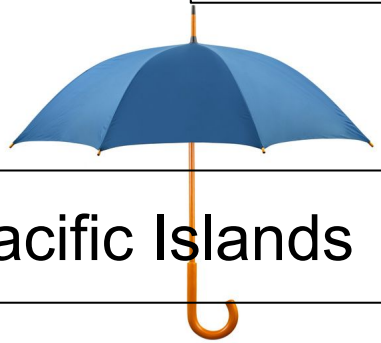


NMFS Climate Science Strategy

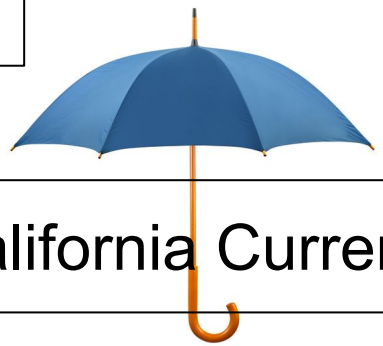
Regional Action Plan for Southeastern Bering Sea Climate Science

Northeast US

Southeast US



Pacific Islands



California Current

Gulf of Mexico

Most important steps to improve efforts to identify and adapt to climate change impacts on fisheries:

- Identify winners and losers and adjust management programs (i.e., catch share programs) as necessary
- Identify and monitor thresholds in ecosystem parameters that signal the need to adjust management strategies

Presenters addressing TOR 1 and 3 (Mike)

TOR 1. Do the Centers/ST have clear goals and objectives for an ecosystem-related science program? Is ecosystem-related science integrated with the other science activities across Divisions within the Center/ST? Are the Center's/ST's ecosystem science and research activities appropriately prioritized and evaluated as part of an overall strategic plan?

TOR 3. Has the Center/ST appropriately established a Regional Action Plan to identify the major climate threats to the ecosystem, identify major vulnerabilities of living marine resources with respect to climate, address the core science needs to address impacts from a changing climate, and integrate this information into management advice, congruent with the NOAA Fisheries Climate Science Strategy1?

Slide titles (for individual slides or sections)

1. Goals and objectives

1.Ecosystem-related science integration

1. Ecosystem science and research prioritization

1. Ecosystem science as part of an overall strategic plan

3. Climate Science Strategy Regional Action Plan

3. Identify the major climate threats

3. Identify major vulnerabilities

3. Address the core science needs

3. Integrate information into management advice